



INTRODUCTION TO PROGRAMS AND RESEARCH ACTIVITIES

By

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WERI

**WATER AND ENVIRONMENTAL RESEARCH INSTITUTE
OF THE WESTERN PACIFIC
UNIVERSITY OF GUAM**

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WERI



Water & Environmental Research Institute of the Western Pacific at the University of Guam

The Water & Environmental Research Institute of the Western Pacific, or WERI, is one of 55 similar water research institutes established by U.S. Congressional legislation at each Land Grant University in the United States and in several territories. The institute is now in its 29th year of operation.

WERI's mission is to seek solutions through research, teaching, and outreach programs, to issues and problems associated with the location, production, distribution, and management of freshwater resources. WERI provides technical expertise, and conducts vigorous research and both undergraduate and graduate teaching programs aimed at improving economic conditions and the quality of life for citizens of Guam and various regional island nations. WERI also runs a state of the technology water analytical laboratory and geographical information systems facility.

WERI administers and carries out research, training, and other information transfer programs under a variety of federal and local funding sources, but the institute was created specifically to administer Department of Interior (US Geological Survey) money under Section 104-B of the National Institute of Water Research (NIWR) 104-B Program. WERI has responsibility for 104-B monies on Guam, in the Commonwealth of the Northern Mariana Islands (CNMI), and in the Federated States of Micronesia (FSM).

In FY-2004 WERI faculty were involved as Principal Investigators on twenty research and training projects with a combined budget of about \$1,047,000: \$278,000 from seven 104-B projects, \$95,000 from three other federal agencies, \$276,000 from Federal sources awarded through Local Agencies, and \$398,000 from local grants and direct funding from the Guam legislature.

Currently WERI has a fulltime director who is also a UOG faculty member, five regular research faculty, two adjunct research faculty, a water analysis laboratory manager and technician, two office staff, as well as five graduate research students who are completing their MS degree in the Environmental Sciences program. During the year 2004, WERI faculty and staff taught eight graduate courses and four undergraduate courses in the Environmental Science MS program and the undergraduate Pre-Engineering curriculums respectively. At the same time WERI faculty were first or second authors on 13 refereed journal articles or conference proceedings, five technical reports, and 9 professional presentations. Currently WERI faculty members serve as committee members on, or chairs of about 12 MS research theses in the Environmental Sciences and Biology graduate programs.

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ACTIVE PROJECTS



**Water & Environmental Research Institute
of the Western Pacific at the University of Guam**

US GEOLOGICAL SURVEY WATER INSTITUTE PROGRAM



GUAM:

**Heavy Metals in Biotic and Abiotic
Components of a Guam Reef Flat Impacted
by Leachate from a Municipal Dump**

**Anthropogenic Impact On Nitrogen Cycle
In Tumon Bay Using 15N, And 14 N
Isotopic Ratio Methods**

**Development of A Digital Watershed Atlas
for Guam**

FSM:

**Watershed Management for Enipein
Watershed, Pohnpei Island, the Federated
States of Micronesia**

**Geologic Study, Map Development, and
Water Resources Analysis of Fais Island,
Yap State, FSM**

FSM atoll groundwater resource inventory

CNMI:

**Development of a Source, Transmission and
Storage model of the Saipan Water System**

OTHER FUNDED PROJECTS

**NATIONAL WEATHER SERVICE
Pacific ENSO Applications Center**

**NATIONAL SCIENCE FOUNDATION
Modeling of Fine-Grained Till Deposits by
the Laurentide Ice Sheet**

**NOAA/GUAM BUREAU OF
STATISTICS AND PLANS**

**Development of Strategies for the
Reduction of Nitrate Contributions from
Septic Tanks to the Stream and Coastal
Waters of Southern Guam**

**NOAA/GUAM COASTAL
MANAGEMENT PROGRAM
Monitoring Study of the Pago Bay
Watershed**

**Development of a Geographic Information
System Based Erosion Potential Model**

**COMMONWEALTH UTILITY
CORPORATION, SAIPAN, CNMI
Water System Model Development For The
Saipan Water Distribution System**

**DIRECT LOCAL FUNDING
Guam Hydrologic Survey**

Water Resources Monitoring Program



Heavy Metals in Biotic and Abiotic Components of a Guam Reef Flat Impacted by Leachate from a Municipal Dump



**Funded by:
US Geological Survey, Water Institute Program
P.I.'s
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Funding: \$31,627**

Pago Bay is a fringing reef flat on the eastern shore of central Guam. It harbors a rich diversity of marine life and supports a variety of scientific, commercial and recreational activities. For the past 50 years, leachate streams emanating from Guam's only municipal dump have been making their way down the Lonfit River and out into Pago Bay. Chemical characterization of the leachate streams has identified heavy metals as the contaminants of primary concern both from an ecological and human health perspective. Specific elements flagged as exceeding toxicity thresholds include arsenic, chromium, copper, iron, lead, manganese, mercury, nickel, silver and zinc. Currently, nothing is known about the movement of these potentially toxic elements into the biotic components of Pago Bay. In view of the commercial, recreational and scientific importance of this area, such a study is long overdue. The study described herein proposes to establish baseline levels of the aforementioned metals in biotic and abiotic components of the bay with emphasis on sediments, bioindicator species and dominant fisheries resources traditionally harvested for food.

Surface sediment samples will be collected at ~100-m intervals along the entire length of the bay and at ~100-m to 200-m intervals along five, approximately equally spaced transect lines running perpendicular to the coast. Biota sampling will focus on dominant groups with high bioindicator potential that are either sessile

or are restricted in their movement. Potential candidates include algae, sea grasses, sea cucumbers, bivalves and gastropod mollusks. These organisms generally have little or no regulatory capacity for some or all of the contaminants in question and hence their tissue levels mirror biologically available amounts derived from their immediate surroundings. They will be collected largely on an opportunistic basis from within the six regions delineated by the sediment transects.

The analytical work will be carried out at the Water and Environmental Research Institute (WERI), Water Quality Laboratory, at the University of Guam, where adequate support facilities, infrastructure, essential chemicals and items of equipment necessary for the study are present. The analytical procedures will follow established methods developed by USEPA and NOAA. Quality control and quality assurance procedures will be rigidly adhered.

Overall, the study will establish a reliable database with which future findings may be compared and evaluated; delineate areas of contaminant enrichment within the study area, and identify potential hot spots. Further, it will assess the degree of contamination in Pago Bay by reference to levels reported for clean and polluted environments elsewhere in the world. Potential health risks (if any) associated with the long-term consumption of edible resources surveyed will also be evaluated.



Anthropogenic Impact On Nitrogen Cycle In Tumon Bay Using ^{15}N , And ^{14}N Isotopic Ratio Methods



Funded by:
US Geological Survey, Water Institute Program
P.I.
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Funding: \$35,264

Algal blooms along Tumon Bay in Guam are a major concern. Tumon Bay is the tourist hub for the island of Guam and the increasing pollution due to nutrient enrichment and subsequent algal bloom is an eyesore and could potentially have negative impact on the tourism industry on the island.

Early studies have clearly shown the excessive growth of green alga *Enteromorpha clathrata*. One of the possible sources comes from freshwater springs that discharges in the form of springs and seeps along the entire bay area. These spring waters flow from aquifers of the northern lens of the island. The levels of nitrates are significantly high enough in these springs to sustain algal population along the estuary. However, the increasing stands of algal bloom may be due to the rapid industrialization along the bay area.

The critical question is what are the major sources of enrichment along the estuary. Clearly the input from the catchment that discharges to the entire bay will need to be considered. Previous studies have focused on determining the levels of nitrogen containing nutrients and phosphate in the receiving waters and the intertidal water zone along the bay. While these data have been useful in confirming the enrichment status, they lack clarity as to the origin of the pollutants. Human impact through fertilizer applications, construction work, commercial operation such as restaurants, shopping malls, certainly have an impact but there is limited data on the extent and its role in the increase of algal growth.

The aims of this study are

- To determine the different forms of nitrogen compounds in the water system on Tumon Bay. This will involve determining the levels of nitrates, nitrites and ammonia in all the possible inputs including those that has been studied
- To determine the isotopic ratio of stable nitrogen isotopes, ^{15}N and ^{14}N at the different components of the nitrogen cycle (water, plants, fish, invertebrates) in order to discriminate the contribution of human or animal waste nitrogen from fertilizer and industrial nitrogen
- To determine the mechanism of nitrogen uptake through the different levels of the nitrogen cycle based on the data collected.
- To compare the findings with previous data on the levels of nitrogen containing nutrients

The results from this study should be able to pinpoint the sources of nitrogen enrichment along the bay and assist the management in designing suitable measures for minimizing pollution. This study will also train student at the university to conduct environmental analysis and deepen their appreciation for chemical processes pertaining to pollutants in the environment. It will also enhance the institute and the department in training on new technique of isotopic methods that will be used in this study.



Development of A Digital Watershed Atlas for Guam



**Funded by:
US Geological Survey, Water Institute Program**

P.I.'s

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Funding: \$35,052

Effective management of island water resources requires accurate information on the physical and environmental components of all the watersheds. There are sixteen (16) watersheds in southern Guam that contribute runoff to the streams and coastal areas. Protecting these watersheds from point and non-point sources of pollution requires a better understanding of the watershed topography, vegetation, soil properties, roads, land use and land cover information, badland and many other features. The watershed's features should be stored and formatted in such a way that it can easily be made available for any water resources study such as; watershed planning and management, estimating upland erosion, impacts of mans activities on the quality and quantity of the streams and lake. In addition, the information should be stored in such a way that it can be easily updated and made available to all interested agencies and researchers. During 1990s, geographical information systems (GIS), with their ability to pull spatial data from different sources into an integrated environment, emerged as a significant tool for hydrologic modeling. Particularly, GIS provided a consistent method for watershed delineation using digital elevation models (DEMs). In this project, GIS and related technologies such as remote sensing and global positioning systems (GPS) will be used to collect, digitize, organize, model and analyze data on watershed characteristics. A geo-database will be established to incorporate physical, environmental and socio-economic information in the watersheds. Remote sensing will be a tool for data updates for the digital watershed atlas. GPS will provide data updating for the GIS database, and be used for some data ground-truthing.

The overall objective of this project is to create an atlas of Southern Guam's watersheds that includes the watershed boundary with its physical and environmental components.

The specific goals are:

- 1) Form a core user group for atlas development. At the startup of the project, the researchers will put together a committee with representatives from the Government of Guam and other related agencies. The role of this committee will be to identify the digital elevation model (DEM) that should be used and what other information should be included in the atlas.
- 2) Develop physical characteristics of watershed layers. During this phase the layers that describe the physical characteristics of the southern Guam watersheds will be assembled. This will include;
 - a) Acquire or develop a standard Digital Elevation Model (DEM) set for the island,
 - b) Develop watershed boundaries for all major basins in South Guam;
 - c) Develop sub-watershed boundaries according to the consensus of the core group,
 - d) Develop stream maps for all the major streams,
 - e) Develop layers showing river mile locations for all major streams,
 - f) Develop stream profiles (graphs of elevation vs. river mile) for all major rivers, and
 - g) Develop slope and slope aspect maps for all of South Guam.
- 3) Develop or acquire existing layers identified as being important by the consensus of the core group. All layers will be projected into one common projection system. Some examples of possible layers might be: soil type, vegetation coverage, fault lines, badlands, and roads.



Watershed Management for Enipein Watershed, Pohnpei Island, the Federated States of Micronesia



Funded by:

**US Geological Survey, Water Institute Program
P.I.'s**

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Funding: \$39,067

The Enipein Watershed that is situated in the Kitti Municipality in the South of Pohnpei Island is unique in many aspects. This area of approximately 10 square miles is home to unique native forests; a spectacular web of rivers, streams and fresh water swamps; and extensive mangrove forests, sea grass beds and coral reefs. According to the Conservation Society of Pohnpei (CSP) many of Pohnpei's 110 endemic plants and 13 endemic bird species along with thousands of other terrestrial and marine creatures are found in this area. One of its most astounding features is the unique occurrence of Pohnpei's only stand of the endemic plant, Pwuhr (*Ragraea berteriana*), mainly used to make mwaramwars (leis). The Enipein Watershed Basin is also unique because it encompasses part of the Pohnpei Watershed Forest Reserve, the whole of the Enipein Mangrove and Marine Sanctuary/Park, and the Nahtik Marine Protected Area. However, with a growing population and need for cash, the Enipein watershed's fragile habitats and invaluable resources are becoming highly threatened. In recent years large areas of native forests and ecologically sensitive areas are being cleared for housing and road development projects and unmanaged agricultural activities (e.g., sakau/kava plantations). These new development activities are now negatively impacting the biodiversity health of the area, the headwaters and freshwater resources as well as the mangrove forests and coral reefs. To implement any watershed management/protection plan requires having a better understanding of the physical and environmental components of the watershed. This includes how much rain the watershed receives, how much flow runs through the streams, what is the sediment load in the

streams during the year, and how all these dynamic components are related to man's activities within the watershed. The lack of baseline information about the components of watersheds is a critical issue throughout the Federated States of Micronesia. When the political status of the Federated States of Micronesia with the United States changed from Trusteeship to Free Association in 1986, all the stream flow gages that were built and monitored by the US Geological Survey were halted and have remained effectively abandoned. Since 1986 there has been no information on how much flow runs through the streams and how much sediment is being carried to the reefs. The objectives of this project are to: 1) install stream flow, sediment, and rain gages for selected sites within the Enipein Watershed; 2) monitor the gages and develop stage discharge rating curves for selected sites; 3) develop a correlation between stream flow, sediment load and rainfall; and 4) develop a database for future use. The result of this project will be development of baseline information and correlations among the dynamic components of the Enipein watershed environment. The baseline information will be used for future comparison between Enipein watershed and other watersheds that have less human activity such as those in Madolenihmw municipality. The results will reveal the impact of the various activities such as land clearing, land sliding/slope failures, and population growth on the quality of the watershed. This information will help various parties such as the Conservation Society of Pohnpei (CSP), Land Management, the Pohnpei EPA, and local mayors to implement plans for protecting the watersheds in Pohnpei.



Geologic Study, Map Development, and Water Resources Analysis of Fais Island, Yap State, FSM

Funded by:

US Geological Survey, Water Institute Program

P.I.'s

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Funding: \$39,838



This project will assess the physical resources and sociocultural factors that must be considered in order to develop a reliable source of potable water to meet the needs of the residents of the small (2.6 km²), remote island of Fais, Yap State, Federated States of Micronesia. Fais's resident population of about 320 people currently relies almost exclusively on rainwater catchments to meet its potable water needs. However, on average once a decade a major storm destroys or damages existing catchments, most recently in November 2003. Groundwater development is limited to one functional well that has demonstrated its potential to provide fresh water and the existence of a natural feature that has been used in past droughts to draw fresh water from the aquifer. Although these resources along with the potential for further groundwater development may establish an excellent emergency supply, the existing rainwater catchment system is operating at less than 25% of its potential. Bringing the catchment system up to its full potential and providing the means to maintain it may produce enough potable water to meet the needs of the people in all but the worst of droughts or storm events. The socio-cultural portion of the project has included an inventory of all catchment areas and storage volumes both in-use and potentially available. Along with a survey of water usage patterns and other demographics these data will provide a basis for evaluating the effectiveness of the existing system, the potential of the system, and an estimate of future demand. Continued development of the groundwater on Fais for dealing with emergencies may be suggested by our findings, and two main issues must be addressed in this case. The small size and

subsistence economy of Fais along with the prevailing traditional social organization and land tenure must be considered in any technical recommendations for development and protection of groundwater. These recommendations must be compatible with the island's social traditions, cultural values, and indigenous authority. The size of the island and the physical constraints on the size and shape of the freshwater lens is also vital to any development projects that could be proposed. Most existing wells provide saline water demonstrating that the prior estimations of the lens' properties and location are inaccurate. The refinement and completion of our map of the key karst features that constrain the drainage, storage and discharge of groundwater is key to this second year of research and will enable future development of this resource. The study will employ the classical methods of geological and anthropological fieldwork. The results will include recommendations for appropriate development and management approaches that will ensure that water from the developed sources will be available when needed. The principal investigators will draw, respectively, from over 10 years of experience in studying the hydrogeology of similar raised carbonate islands in the region and 35 years of personal association with residents of Fais. Finally, the project will support the second year of a graduate thesis project in Environmental Science at the University of Guam for a graduate research assistant who will continue to be trained on a broad range of graduate academic topics, including hydrology, hydrogeology, cultural anthropology, environmental economics and management, and the use of databases and GIS.



FSM atoll groundwater resource inventory



Funded by:
US Geological Survey, Water Institute Program
P.I.'s
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Funding: \$21,199

Atoll islands are uniquely vulnerable to drought. During the most severe droughts production from rooftop rain catchments ceases completely, and groundwater can become too saline for human consumption, or even disappear entirely as the shallow, thin groundwater lenses of the atoll islands become depleted. State officials and island leaders in the Federated States of Micronesia need reliable estimates of the amount and rates at which water can be extracted under drought conditions, and the rate at which the freshwater lens can be expected to recover as precipitation returns to normal. Such knowledge will enable more effective management of emergency water supplies during droughts and provide a basis for sustainable management. The research team will conduct a comprehensive literature and database search on the geology and hydrology of Pacific atoll islands, from which information will be extracted and compiled into a GIS database. Using the geological and hydrological data thus gained, they will incorporate static (steady-state) analytical equations into a GIS model to calculate groundwater reserve and sustainability estimates for each atoll island in the database. During the summer field season the team will also make a brief visit to Mokil Atoll, Pohnpei State, FSM, to substantiate the applicability of the GIS model by field checking the underlying assumptions and methodology against actual conditions on a representative atoll island. They will interview residents to learn about

their water use practices and needs. Specific objectives of the literature/database search include collecting the following information for each of the atoll islands in the FSM:

Island locations, geographical dimensions, and hydrogeological data (e.g., hydraulic conductivity, water table response to tides) gleaned from previous studies by others.

Land use information on each island, to include the proportion of each island covered by various types of vegetation, both natural and agricultural, and the evapotranspiration characteristics of the vegetation.

Meteorological information for each island, to include historical rainfall records and regional estimates, where data on individual atolls are unavailable.

Demographic information related to water use, such as population and daily water consumption, types of use, usage patterns, and responses to previous droughts. Specific objectives for the GIS database and hydrologic model to be constructed for the project include the following:

Estimates of the steady-state groundwater reserve associated with rainfall over the range of interest—i.e., historically normal to historically low rainfall amounts.

Estimates of the rate and amount of water that could be extracted from each island aquifer under drought conditions.

Estimates of the rate at which island groundwater reserves can be expected to recover as rainfall returns to normal.



Development of a Source, Transmission and Storage model of the Saipan Water System



Funded by:

**US Geological Survey, Water Institute Program
P.I.'s**

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Funding: \$21,745

Water hours and low delivery pressure have long been a part of the daily lives of the people in the islands of the Western Pacific. In Saipan, Commonwealth Northern Marianas Islands (CNMI), large investments have been made in system improvements, but delivery problems still exist. A stated goal of the CNMI government is to provide 24-hour water to all residents served by the Commonwealth Utility Corporation (CUC) water system. This goal will be unattainable until the CUC has a complete knowledge of their water delivery capabilities and operation. Over the years the CUC water distribution system has grown and new wells have been added to the system. This physical expansion has been well documented but improvements in the hydraulic characteristics and delivery capabilities of the entire system have never been fully examined. The Saipan water distribution system has been divided into 10 sub-regions. Each region is expected to operate somewhat independently. However, due to inadequate inflow to the system, system leakage, and lack of knowledge of the system behavior as a whole the system is unable to provide 24-hour water services. Recently WERI researchers have developed computerized models of each of the ten sub-regions of the CUC water system using the Haestad WaterCad water system modeling program. This model includes a physical system description, details of water usage, and parameters describing system operation. The next step needed is to examine the entire system behavior when the main distribution lines for each of the sub-systems are connected together. The benefits expected from the project include a better understanding of the adequacy of the existing pumps and well systems, the

adequacy of the existing storage facilities to provide for daily fluctuating demands, the ability of the well and storage system to provide sufficient flows, and a more in depth understanding of the most efficient means to move water from water supply rich regions to those that have supply shortages in order to maintain delivery of 24 hour water to all areas in the system. The project will be split into two phases. The first phase will start from the 10-system water models previously developed of the Saipan Water System. These models will be skeletonized to remove all but the major water sources, tanks and transmission components and joined together at the boundary points. We will work closely with CUC Engineering staff to be sure all included components are correctly modeled. The model will be calibrated by comparing model predicted pressures and flows with those existing in the system. The second phase will determine the optimum system operation. This phase will be accomplished in close consultation with CUC staff engineers. First the model will be operated in steady state mode and the response of the system during critical times will be examined to determine if the system can meet the required demands and if not what changes in either operation or physical make up of the system would be required to solve the problems. Next the model would be operated in extended time simulation mode to examine storage tank operations. The response of the storage tanks over time will be examined to determine if all of the tanks are operating in an optimal manner and if not what changes in either operation or physical make up of the system would be required to improve tank operations.



PROJECTS COMPLETED MARCH 2005



**Water & Environmental Research Institute
of the Western Pacific at the University of Guam**

US GEOLOGICAL SURVEY WATER INSTITUTE PROGRAM



GUAM:

Speciation studies of arsenic in Guam Waters Phase II

Presence and Survival of Fecal Indicator Bacteria in Soil from the Banks of Major Rivers and Streams on Guam

FSM:

Groundwater Development and Utilization for Emergency Drinking Water Supply on Fais, Yap State, FSM

Refining the Rainfall Erosivity Factors and Developing Rainfall Distribution Maps for the Island of Pohnpei

Qualitative examination of groundwater from Yap and some of its neighboring islands

A water quality study of river and ground water resources in Kosrae, FSM

CNMI:

Persistent Contaminant Assessment of Food Fish from Tanapag Lagoon, Saipan

Hydrology of the Sabana Watershed and Water Cave, Rota, CNM



Speciation Studies of Arsenic in Guam Waters: Phase II

Funded by:

US Geological Survey, Water Institute Program
P.I.

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Funding: \$31,199



Arsenic is a ubiquitous element and is present in minerals, sediment and water. Arsenic contamination in water has received significant attention over the last few years due to its carcinogenic properties. There had been reported incidences of arsenic contamination in drinking waters in the US and also internationally. US EPA has recently revised the Maximum Contamination Level for As to 10ppb.

Guam's main water source is from a limestone aquifer that lies in the northern half of the island. An estimated 80% of the total water source is derived from the aquifer and the remaining comes from surface water sources located in the southern part of the island. There are more than 100 wells that serve the population and most of these are located on the northern part of the island. Some of these wells are connected through conduits that flow out through springs along Tumon Bay. Initial studies in 2001 conducted by Guam EPA along the Tumon Bay springs show unusually high levels of arsenic from these springs. This was followed up with speciation studies of arsenic along the same springs. Results from the speciation study show low levels of arsenic. The big differences in the two sets of data and the differences in methodology used renders these data inconclusive. Further investigation is required to verify these data. The aim of this project is to verify the differences from the two studies and to also extend the investigation into sediments and biological materials to establish the possible sinks and the mobilization conditions for arsenic species.

The objectives are:

1. To investigate the levels of Arsenic in Tumon Bay, the connecting freshwater wells on Guam and other potential sites during the wet and dry seasons.
2. To conduct speciation studies of arsenic to ascertain the levels of the different forms of As both organic and inorganic.
3. To conduct speciation study on the sediments and biota samples.
4. To conduct an inter-laboratory validation exercise.
5. To correlate the levels of arsenic to the likely sources and sinks.
6. To relate these levels to the parameters; pH, alkalinity, salinity, dissolved oxygen.

The hydride generation method coupled with Atomic Absorption Spectroscopy that was successfully developed from the first part of this study has shown adequate differentiation between the inorganic arsenic(III) and arsenic(V) species. Part of this continuing project will be to develop and set up the method for differentiating the organic forms of arsenic. For this the Gas Chromatograph and High Performance Liquid Chromatography (HPLC) method will be used. Water samples will be collected from the Tumon Bay area, ground water wells, and other potential contamination sites for comparison. Sediments and biological samples will also be collected from the study sites. This study will establish the levels and the forms of arsenic in the environment and will show whether there is any threat of arsenic contamination in Guam waters. It will also explain the differences from the two studies. The data will assist the relevant authorities in Guam on monitoring and designing management guidelines to address any potential threat to the environment. It will also provide necessary training and skills for speciation studies and analytical instrumentation experience for graduate and under graduate students at the University of Guam.



Presence and Survival of Fecal Indicator Bacteria in Soil from the Banks of Major Rivers and Streams on Guam



Funded by:
US Geological Survey, Water Institute Program
P.I.

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Funding: \$38,822

The use of fecal bacteria to monitor the hygienic quality of recreational waters has some serious limitations in many tropical and subtropical regions of the world. This is because favorable ambient temperatures encourage extended survival times of these organisms in the environment and dramatically increases the risk of false positives occurring. On Guam, *E. coli* and enterococci are used to monitor rivers and coastal waters around the island respectively. Both organisms have been observed to survive indefinitely in sediments and soils in Hawaii, Puerto Rico, southern Florida, and northern Australia. Their growth in various environmental media has also been reported in several instances. While the survival, growth and proliferation of *E. coli* and enterococci is suspected to occur in sediments and soils on Guam, the limited available data is inconclusive because it fails to differentiate between possible contributions from fecal and non-fecal sources. The fact remains, however, that exceedances of the recreational water quality standards are far more frequent during wet weather than they are during dry periods. This strongly suggests that local riverbank soil is a major reservoir for enterococci, and that these bacteria are mobilized into the coastal belt by erosive processes during prolonged periods of heavy rain.

The objectives of the study described herein are to demonstrate whether or not *E. coli* and enterococci are capable of surviving in Guam riverbank soils over extended periods of time, and to elucidate the importance of various soil related factors that might influence the data. To this end, we propose to screen riverbank soils for *E. coli* and enterococci from all major rivers and streams on island. Sampling sites will coincide with those adopted by Guam EPA for recreational water quality monitoring

purposes. Subsequent investigations, at selected sites, will explore any horizontal and vertical variations in abundance of both organism in relation to soil type, organic matter content, nutrient levels, and moisture content. We will also attempt to determine their survivability in the total absence of sustainable sources of fecal bacteria such as storm water runoff and animal excrement.

Fecal bacteria will be removed from all soil samples by sonic probe and cultured using Colilert® and Enterolert® commercial growth media for *E. coli* and enterococci respectively. Bacterial enumerations will be accomplished using the Quanti-Tray™ MPN method following incubation at 41°C for 18 h ± 2 h for both organisms. All soils tested during the study will be characterized according to type, and analyzed for organic carbon, nitrate, orthophosphate, total nitrogen, total phosphorus and moisture content. Survival tests will be conducted using closed-jar microcosms.

The analytical work will be carried out at the Water and Environmental Research Institute (WERI), Water Quality Laboratory, at the University of Guam, where adequate support facilities, infrastructure and equipment necessary for the study are present. The analytical procedures will adopt USEPA approved methods in all instances. Quality control and quality assurance procedures will be rigidly adhered to.

The data obtained should command the attention of water quality managers, environmental regulators and public health officials in tropical and sub-tropical regions throughout the world.



Groundwater Development and Utilization for Emergency Drinking Water Supply on Fais, Yap State, FSM



Funded by:

**US Geological Survey, Water Institute Program
P.I.'s**

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Funding: \$53,220

This project will provide an assessment of the physical resources and socio-cultural factors that must be considered to develop a reliable source of potable groundwater to meet emergency needs of the residents of the small (2.6 km²), remote island of Fais, Yap State, Federated States of Micronesia. Fais's permanent population of about 320 people currently relies almost exclusively on rainwater catchments to meet its potable water needs. However, on average once a decade a major storm destroys or damages existing catchments, most recently in November 2003. Groundwater, however, has yet to be developed, even for emergency supply. To do so requires first making a general survey to locate prospective sites that could yield sufficient quantities of potable water under emergency conditions. Moreover, in light of the small size and subsistence economy of Fais and the prevailing traditional social organization and land tenure, technical recommendations for development and protection of groundwater must be compatible with the island's social traditions, cultural values, and indigenous authority. The central objective of this study will therefore be to map the key karst features that constrain the catchment, storage, and discharge of groundwater, and prepare preliminary maps of potential sources within the inferred catchment areas that can serve for planning and engineering purposes in the immediate future. The

supporting but equally important objectives of the socio-cultural portion of the project include making an inventory of patterns of usage, storage, and sharing of water from existing rainwater catchments and other sources. Collection of demographic data, in addition, will provide a basis for evaluating foreseeable future water resource needs. The study will employ the classical methods of geological and anthropological fieldwork. The expected result will be a preliminary map of potential groundwater resources that could be developed for emergency needs, with recommendations for appropriate development and management approaches that will ensure that water from the developed sources will be available when needed. The principal investigators will draw, respectively from over 10 years of experience in studying the hydrogeology of similar raised carbonate island in the region and 35 years of personal association with residents of Fais. Finally, the project will support a graduate thesis in the Environmental Science program at the University of Guam. The graduate research assistant will be trained on a broad range of graduate academic topics, including hydrology, hydrogeology, cultural anthropology, environmental economics and management, and the use of databases and GIS.



Refining the Rainfall Erosivity Factor and Developing Rainfall Distribution Maps for the Island of Pohnpei



Funded by:

**US Geological Survey, Water Institute Program
P.I.'s**

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Funding: \$36,803

In Micronesia, where tropical cyclones and other manifestations of deep convection are common, very high short-term rain rates are experienced. We have chosen the island of Pohnpei to set up a network of manual and electronic rain gages to study the spatial and temporal distribution of rain. Located at low latitude in the western North Pacific (where deep convection in various organized patterns and stages of development is the dominant producer of rain), the island of Pohnpei is one of the wettest places on earth. Our recently installed rain gage network indicates that the high interior of the island may receive over 300 inches of rain annually. Stream and urban flooding as well as deadly slope failures are recurring problems on Pohnpei.

Human activity and other factors are changing the physical and biological character of Pohnpei's unique tropical rain forest. Insufficient spatial distribution of rain gages and lack of appropriate measurements of short-term extreme rain rates have resulted in rainfall statistics for most of the islands of Micronesia that are incomplete, inaccurate, and/or non-existent for many areas.

This has created problems in many areas such as:

- (1) Difficulty in estimating the rainfall erosivity factors that are being used for erosion protection and identification of landslide areas.
- (2) Difficulty in developing infrastructure for storage and distribution of surface water.
- (3) Difficulty for disaster managers to better understand the processes that

lead to slope failure and local stream flooding; and,

- (4) Difficulty in the planning and design of hydro electrical power plants.

The objective of this project is to acquire, compile, and analyze rainfall data from a transect of manual and electronic rain gages (some already installed and some others to be placed at crucial locations) to produce statistics of rain fall needed to address land and surface-water management problems, and to help identify the character and thresholds of rainfall that lead to dangerous flooding and slope failures. A key parameter we wish to determine are the R-factors that govern erosion on the island. The R factors are related to the peak 15-minute rain rates, and this data is only now beginning to be acquired. With our newly acquired rainfall dataset, we will be able to refine the maps of the distribution of the R factor on the Island. Also, a complete description of the hydrologic cycle on Pohnpei is not complete without some assessment of the magnitude of fog drip in the interior highlands that are often enshrouded in cloud. In order to get better information on the possible contribution of fog drip to the total annual precipitation in Pohnpei's rain forest, we will install a fog-drip collector at our mountain rain gage site.



A water quality study of river and ground water resources in Kosrae, FSM



Funded by:
US Geological Survey, Water Institute Program
P.I.'s
Puthiyaparambil Josekutty Josek64@yahoo.com
Funding: \$26,138

Kosrae, Federated States of Micronesia (FSM) is a small state comprising of a single island with a population of little over 10,000. Most of the residents live up to an elevation of 600 ft. from MSL though the highest elevation of the island (mountain) is 2500 ft. In Kosrae, river water is the drinking water for many households. Invariably, everyone uses river water for all purposes. Small dams are built on the top of hills, and the river water is channeled through pipes to reach households. Neither water filtration nor chemical treatment is carried out to make the water safe for drinking and washing. Therefore, the water supplied is prone to contamination by potentially harmful bacteria and other microorganisms associated with human and animal wastes in the area. The small rivers (streams) have very little flow except during very rainy periods making the water more prone to contamination from extraneous sources. Waste from the many piggeries on the riverbanks and other human wastes like food, plastics, chemicals etc makes up the bulk of the pollution. Also, there is no common cemetery in the island and the dead members of the family are buried close to the households posing a contamination threat to the underlying groundwater. Many households use water catchment when rain is sufficient. However in years of less rain like 2003, the catchments are not sufficient and river water supply becomes less. Even when the catchment water is sufficient, it is necessary to check and ensure quality of that water is suitable for drinking. Shortage of trained manpower in the area of water quality testing and limited funding makes it difficult to implement regular monitoring of

the island's drinking water resources. Equipment needed for water quality analysis is generally not available locally. There is one pure water company on Kosrae that sells clean, ground water but it is not affordable to a majority of the households. A detailed survey of physical, chemical and biological water quality characteristics of Kosrae's drinking water resources has yet to be undertaken. Therefore this project will attempt a detailed water quality study for river waters from the various dams, downstream (human inhabited areas) and ground water from the four municipalities in Kosrae. The study will examine Total Dissolved Solids (TDS), pH, alkalinity, hardness, nitrate, phosphate, sulfate, carbonate, several heavy metals. Testing for the fecal indicator bacteria E.coli and enterococcus will also be carried out.

This information will greatly help policy makers to come up with the necessary resources for treatment facilities. Results will also benefit Kosrae State administration to formulate sound strategies for the protection of reservoirs and habitat management to control water pollution. Commercially available test kits, and bacteriological growth media will be used to carry out the investigations. Samples for heavy metal analysis will be preserved on island and sent to WERI. Where test kits are not available for accurate analysis samples will be send to WERI, University of Guam, or other nearby centers for water quality analysis. One student from Kosrae will be trained in water quality analysis through this project.



Qualitative examination of groundwater from Yap and some of its neighboring islands



Funded by:
US Geological Survey, Water Institute Program
P.I.'s

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Funding: \$29,315

Over 50 percent of the Yap Island's population utilizes groundwater as its drinking water source, the quality of which is unknown. No qualitative examination of groundwater samples has ever been conducted owing to the economic and other infrastructure constraints of Yap State Public Service Corporation (YSPSC), the establishment responsible for water treatment and distribution. Consequently, groundwater contamination caused by pathogens or chemicals remains undetected. Current treatment facility at Colonia (Central Water System) is able to supply nearly 500,000 gallons of treated water daily for a population of about 3500. Declining Compact Grants from United States in recent years and lack of necessary infrastructure facilities and trained work force makes it difficult for YSPSC or Yap State Environmental Protection Agency (EPA) to conduct periodic monitoring of water sources. The limited number of water reservoirs in the State that exist close to the human habitation makes these storage sites a very likely source of contamination and thereby water borne diseases. The proposed research project involves a three-way collaboration between the Agricultural Experiment Station, Yap Campus (College of Micronesia-FSM), Water Services Division (YSPSC) and Yap State EPA. The objectives are to (i) conduct a quality assessment of groundwater samples collected from different localities of Yap State

including three of its main inhabited neighboring islands (ii) establish baseline information on the present condition of the vital resource, and (iii) train YSPSC and Yap State EPA personnel in carrying out various water qualities testing procedures. Using a set of portable equipment coupled with commercially available test kits and laboratory exercise, we will analyze water samples for biological and mineral qualities. Biological quality, such as coliform content etc., is of particular concern as a health consideration for drinking water. Besides, tests will also be carried out for Total Dissolved Solids (TDS), pH, alkalinity, nitrate, sulfate, phosphate, potassium, carbonate, chloride and other basic elements/minerals. Service of private laboratories will seek to conduct certain tests. Data obtained will serve as a benchmark for comparison with the information that gathers during future monitoring programs. Trainees of this program will be technical representatives from YSPSC and Yap State EPA.



Persistent Contaminant Assessment of Food Fish from Tanapag Lagoon, Saipan



**Funded by:
US Geological Survey, Water Institute Program
P.I.'s**

**Dr. Gary R. Denton (gdenton@uog.edu), Harold R. Wood
Brian Bearden, Peter Houk, Michael Trianni
Funding: \$38,099**

Tanapag Lagoon borders the western shore of central Saipan. It harbors a rich diversity of marine life and supports a variety of commercial and recreational activities. Over the last quarter century, Tanapag Lagoon has become heavily impacted by the activities of man. Primary sources of anthropogenic disturbance in these waters include a power station and commercial port (Saipan Harbor), two small boat marinas, a sewer outfall, several garment factories, auto and boat repair shops, wood shops, government vehicle maintenance yards, a commercial laundry, and an acetylene gas producer. There are also a number of old military dumps and disposal sites in the area as well as a 50-year-old municipal dump that served as the island's only solid waste disposal site until its closure a little over a year ago.

Several streams and storm drains empty into the lagoon during the rainy season and provide a mode of transport into the ocean for any land-based contaminants. Overflows from sewer lines are also commonplace at this time of the year and the whole area is inundated by storm water runoff during periods of prolonged wet weather. The effects of these perturbations on the indigenous biota within the lagoon are largely unknown. Likewise, fundamental data describing the abundance and distribution of persistent and potentially toxic pollutants within the system is also lacking.

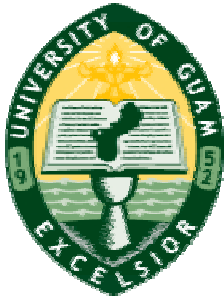
Mindful of these shortcomings, a contaminant assessment of surface sediments within Tanapag Lagoon was recently completed and a bio-indicator survey of the near shore waters is currently underway. The project described herein

proposes to determine contaminants of potential concern (heavy metals, pesticides and PCBs) in important food fishes from within the lagoon and is seen as a logical extension of these studies.

The study will focus on those species commonly taken by local fishermen for food and recreational purposes. Emphasis will be given to fish that are relatively restricted in their movement and spend much if not all of their time in the lagoon. Sampling will be conducted in sea grass beds and patch reef areas throughout the lagoon encompassing both near shore and offshore habitats. Specimens will be collected by cast-net, beach-seine, spear gun, and hook and line. The assistance of local personnel and government agencies in procuring samples will be obtained as necessary.

The analytical work will be carried out at the Water and Environmental Research Institute (WERI), Water Quality Laboratory, at the University of Guam, where adequate support facilities, infrastructure, essential chemicals and items of equipment necessary for the study are present.

The primary objectives of the study are to evaluate contaminant levels in popular table fish from within the lagoon and identify potential health risks (if any) associated with their long-term ingestion. By including territorial species the results will also help identify and delineate areas of contaminant enrichment, and add significantly to the contaminant database required for future trend monitoring purposes.



Hydrology of the Sabana Watershed and Water Cave, Rota, CNMI



Funded by:
US Geological Survey, Water Institute Program
P.I.

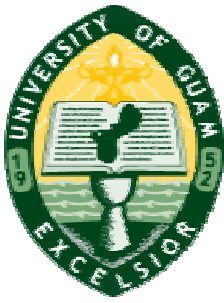
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Funding: \$37,475

Rota, about 40 miles (64 km) north of Guam, supports a population of about 2500. The island obtains nearly all of its potable water from a karst spring estimated to produce from 0.5 to 1.5 mgd (0.02 to 0.06 m³/sec). Although the spring has historically produced more than enough water during wet years, it can slow to very low flow during dry years, nearly ceasing entirely during the 1998 El Nino event. Reliable management of the water production over the long term requires a better understanding of the hydrology of the Water Cave and the catchment that feeds it. In a previous study of Rota led by the author of this proposal, several sink points in the Mount Sabana area have been documented and are suspected to feed the spring. The Sabana area is undergoing active use, including the cultivation of crops in the watershed that feeds the sink points, and hence ultimately the spring. For the island to effectively manage this preeminent water source, it is crucial that engineers and planners have a better understanding of the properties of the Sabana Watershed and the hydrologic connection between the watershed and spring.

The proposed study would produce a set of maps of the Sabana Watershed boundaries, geologic contacts, vegetation, and land use. The maps would also include field relationships of the important hydro geological

features, particularly the locations of the sink points and the inferred and observed flow paths to them. This work would be concurrent with parallel work by the US Geological Survey Field Office in the CNMI in collaboration with the Army Corps of Engineers (Capital Improvement Program) to reinstall a rain gauge in the Sabana Watershed, along with new stage gauging instruments in the spring, both of which were destroyed by a typhoon in July of 2002. The proposed project would use rainfall and spring hydrograph data obtained by the USGS Field Office from Spring of 2001 through July of 2002, along with new data. These data would be used to prepare a water budget for the watershed-spring system and to elucidate the relationship between rainfall, watershed characteristics, storm water runoff and ponding at the sink points, transport time to the spring, and stage response of the spring. They will also provide a basis for predicting the response of the spring to rainfall and to develop a hypothesis for pathways and flow rates in the aquifer. For resource managers and planners on Rota, the results of the proposed work will provide a basis for assessing the risk to water quality posed by human activities in the Sabana Watershed, along with appropriate strategies for aquifer protection and remediation.



Environmental Science Graduate Program University of Guam



The Environmental Science Program is designed to provide students with an appreciation of the interdisciplinary nature of environmental problems that exist in the world today and prepare them for professional employment, teaching or advanced studies in diverse areas of environmental science or related disciplines. The program also serves working professionals in local schools, government agencies and the private sector who are seeking career advancement and/or professional enrichment, e.g., educators, regulators, administrators and planners.

The interdisciplinary focus of the program is intended to train students to identify and understand environmental problems and exercise sound judgment in effecting their remediation. This is accomplished through a careful blend of core courses and electives in an integrated teaching-research approach. Students are required to conduct a research project and document their study in thesis form. They are encouraged to present their findings in a variety of forums (e.g., society meetings, conferences, workshops, seminars, peer-reviewed journals, technical reports, newsletters and the local newspaper). Students also have the opportunity to serve out an internship with a local environmental or engineering firm, or an appropriate Government of Guam or Federal Government Agency. This permits them to gain professional problem solving skills in the

environmental market place. Students who graduate from the MS program can, therefore, reasonably expect to enter professional employment in a variety of areas in the public and private sectors where an understanding of the complex interdisciplinary scientific, social, and political dimensions posed by environmental problems is increasingly necessary.

The Environmental Science Program strives to promote educational and service projects within island communities of the Western Pacific, and attract a broadly based group of scholars committed to seeking answers to the many environmental questions that are arising in developing island nations of the tropical Pacific Basin. Areas of faculty expertise center around three broad areas of concentration namely, biology-ecology, geosciences-engineering, and management. Further information may be obtained from the Program Chair, **Dr. Ross Miller**, telephone: (671) 735-2141, **e-mail: rmiller@uog.edu**.



Pre Engineering Program University of Guam



Engineers are society's problem solvers. They take the theoretical ideas of the scientist and bring them into reality in today's world for the benefit of mankind. Engineers are involved with projects that vary from the design and construction of transportation systems to the planning of the space stations of the future. Nearly all aspects of our lives are touched by the projects worked on by people in the various engineering fields.

WHAT IS PRE-ENGINEERING AT THE UNIVERSITY OF GUAM?

The University of Guam offers a program in Engineering Science that parallels the engineering programs offered during the first two years at major colleges and universities.

The first two years of engineering study places emphasis on learning the tools and theories and providing the background for all engineering fields. Rigorous studies in mathematics and the physical sciences are required of all students. Students are also required to take courses in the social sciences and humanities to round out their educational experience.

WHAT IF I AM NOT SURE IF I REALLY WANT TO BE AN ENGINEER?

Each fall semester the University of Guam offers a course titled "INTRODUCTION TO ENGINEERING". This course is designed to acquaint students to the engineering profession. Discussions are held on all of the various engineering fields. Educational and

professional registration requirements are also introduced. Various guest speakers relate their experiences in the real world of engineering. Finally, students get a taste of the problem-solving techniques used by engineering students and practicing engineers.

WHAT IF I HAVE A WEAK BACKGROUND IN MATHEMATICS AND THE PHYSICAL SCIENCES?

Engineering requires a strong aptitude for both math and science. For students with these kinds of aptitudes but with weaknesses in prior training, there are remedial classes available to help bring the student up to a competitive level. These students will require more than the normal two years to complete the Pre-Engineering Program.

WHERE CAN I GET MORE INFORMATION?

For more information on the Pre-Engineering Program, contact the University of Guam Counseling Center, the Dean of the College of Natural and Applied Sciences, or contact **Dr. Shahram Khosrowpanah** (khosrow@uog.edu) or **Dr. Leroy Heitz** (lheitz@uog.edu) at the Water and Environmental Research Institute of the Western Pacific, UOG Station, Mangilao, Guam 96923 (telephone number **(671) 735-2685**).